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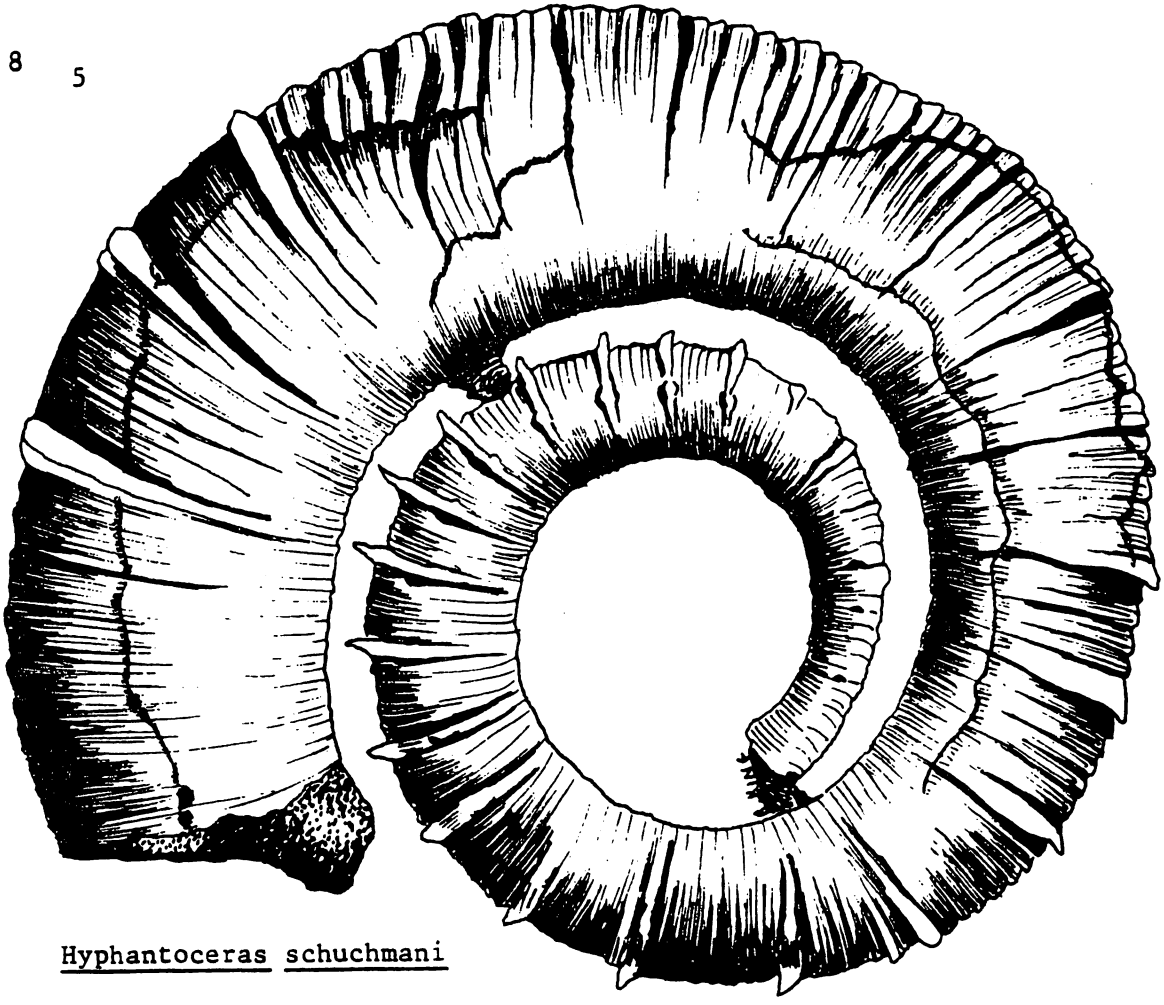
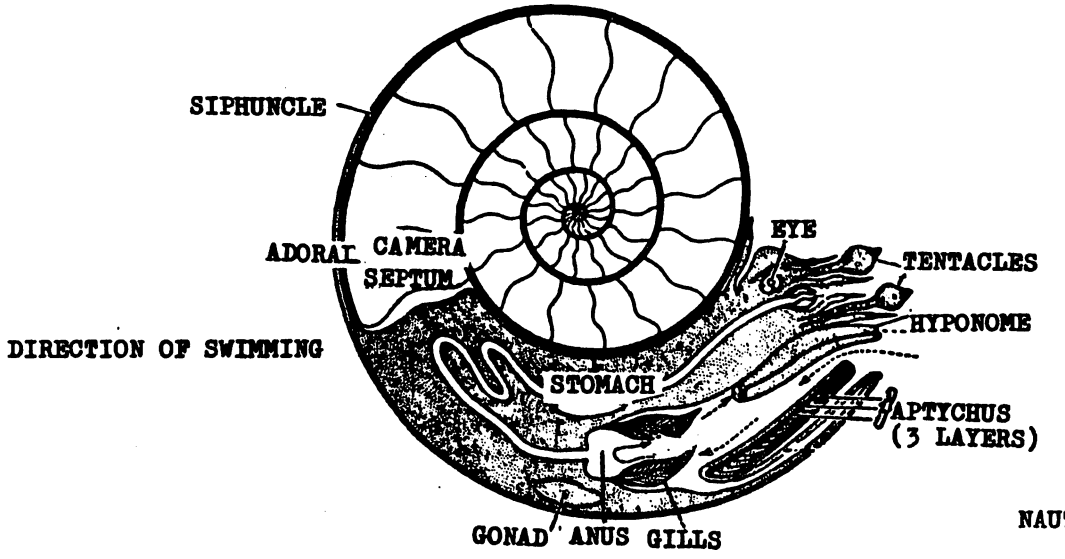


Hyphantoceras schuchmani

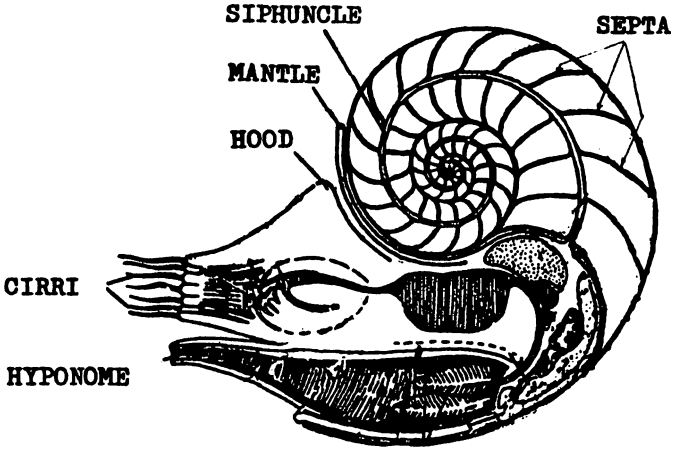
A LOVE OF FOSSILS BRINGS US TOGETHER

C E P H A L O P O D A

AMMONOIDEA CROSS SECTION



NAUTILOID CROSS SECTION



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COVER: Hyphantoceras schuchmani (Haggart) sp., Upper Cretaceous (Santonian), Chico Formation, Northern California. This type specimen is now located in the collections of University of California Berkeley, gift by Clarence Schuchman.

Dissertation, November, 1984, University of California Davis, New Collections of Ammonites From The Upper Cretaceous of Northern California And Stratigraphic Implications, James Walter Haggart, Ph.D. pp. 250 ff. pl. 27. The genus Hyphantoceras has been known chiefly from Japan where spectacular specimens (mostly Campanian) have been described for some time. No really definitive specimens have been reported on this side of the Pacific until five or six years ago when Schuchman began to explore some little known and newly discovered exposures in Northern California. Haggart has described three new species (Santonian), H. schuchmani, H. sauli, and H. ishii, specimens with such utterly spectacular preservation that Dr. Peter Ward was heard to say of one, "This is the best fossil I have ever seen".

ART: B. King, Davenport, Iowa

THE NAUTILOIDS

by John Catalani
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Introduction Cephalopods are the most specialized and highly organized of all the mollusks and their complex structure and efficient metabolic system is unparalleled among unsegmented invertebrates. Today, as in the past, cephalopods are exclusively marine carnivorous predators. There are about 650 species living today but over 10,000 fossil species are recognized.

The one structure that is unique to the cephalopods, setting them apart from the other mollusks, is the siphuncle, the tubular structure that runs the length of the shell or conch, piercing each chamber wall. It is the development of this structure in primitive mollusks known as monoplacophorans that gave rise to the cephalopods, not just the development of chamber formation (Yochelson et. al., 1973).

Ecologic relationships and individual habitats for nautiloids are difficult to determine. Post-mortem distribution of floating conchs due to currents and tides as well as seasonal and monthly migrations redeposited shells of many, but not all, nautiloids in preservation sites often far removed from habitat areas. Recent studies by Westermann (1973) on ocean depth limits based on calculated strengths of the concave chamber walls indicate that the nautiloids could range from 50 meters to over 300 meters with the straight shelled giants and some coiled forms able to descend the deepest.

As many of you know, I have been interested in cephalopods (in particular the nautiloids of the Middle Ordovician Platteville and Galena Groups of northern Illinois and southern Wisconsin) for many years. Dr. Rousseau H. Flower and I are working on a paper of new genera and species which will be only one of several concerning new nautiloids of the Platteville that will be published in the (hopefully) near future. In this article I will attempt to summarize the classification, morphology and identification of the nautiloids with particular references to the nautiloids of the Platteville.

Classification Early classifications were made by zoologists who naturally used living cephalopods as the basis of these classification schemes. They divided the cephalopods into two divisions:

1. Tetrabranchia, possessing two pairs of gills and an external shell, containing the living Nautilus and fossil ammonite and nautiloid forms; and
2. Dibranchia, possessing one pair of gills with the shell internal or absent, containing the living octopus and squid species and the fossil belemnites.

This classification, and its many equivalents, has been rejected for several reasons including the fact that it is impossible to ascertain the number of gills in fossil forms. Also, there are good indications (for one, modern primitive gastropods are dibranchiate) that the first ancestral mollusk, as well as the first cephalopods, had a single pair of gills.

The editors of the Treatise, for the above reasons and others (Treatise, p. K11), modified the classification proposed by Shimanskiy and Zhuravleva (1961, Published in the USSR) to produce the following (with orders given only for the nautiloids):

Class Cephalopoda

- Subclass Nautiloidea (orders: Ellesmerocerida, Orthocerida, Ascocerida, Oncocerida, Discosorida, Tarphycerida, Barrandeocerida, Nautilida)
- Subclass Endoceratoidea (orders: Endocerida, Intejocerida)
- Subclass Actinoceratoidea (order: Actinocerida)
- Subclass Bactritoidea
- Subclass Ammonoidea
- Subclass Coleoidea

I know of two additional orders (Yanhecerida in the Endoceratoidea and Protactinocerida in the Actinoceratoidea) that have been proposed by Chen et. al (1979, Published in China). However, I do not know if they have been formally accepted as valid.

The subclasses Nautiloidea, Endoceratoidea and Actinoceratoidea comprise what is informally known as "the nautiloids".

Morphology The first consideration when studying cephalopods is the orientation of the conch. The ventral side or venter is the under surface of the conch and is the side where the hyponomic sinus is located. (Fig. 1 shows the features mentioned in this section.) The hyponomic sinus is an indentation in the aperature where the hyponome (used for locomotion and respiration) of the living animal was located. If the hyponomic sinus is not preserved, the venter is taken to be the side where the siphuncle is located. The dorsal side or dorsum is the upper surface, and between the venter and the dorsum are located the lateral sides.

The conch itself is divided into two parts, the anterior living chamber and the phragmocene with its posterior termination at the protoconch or initial chamber. The living chamber, as the name implies, is that part of the shell where the animal lived. The opening of the living chamber is called the aperture which allowed the animal access to its environment. As has already been mentioned, the indentation of the aperature at the venter is known as the hyponomic sinus.

The phragmocone contains all remaining structures many of which are used for classification and identification at the generic and species level. The phragmocone is divided into many camerae or chambers by a series of concave partitions called septa or chamber walls. Each camera represents part of a former living chamber that the animal closed off by the secretion of a septum as it grew larger and extended its shell. On steinkerns (fossilized remains of the inner portion of conchs without the outer shell covering--most nautiloids are preserved in this manner), the outer edge of the septa form transverse markings called sutures which can be straight around the conch or display various lobes (bends away from the aperture) or saddles (bends toward the aperture). As most of the nautiloids approached maturity, the spacing between the septa began to decrease (the chambers became smaller). This reflects final fine-tuning adjustments to achieve the neutral buoyancy needed for the remainder of its life and is variable from one individual to another usually affecting the final 2-6 septa (sutures on the steinkern surfaces).

The camerae located at the posterior end can have a series of structures called cameral deposits which are usually present only in the large straight-shelled nautiloids. Whereas many early workers said that these were inorganic fossilization structures, Flower correctly interpreted them to be organic secretions which increased in mass as the animal grew and which were used to counterbalance the mass of the living animal and to overcome the buoyancy of the phragmocone in order to keep the animal in a comfortable horizontal position (instead of the awkward vertical position that was at one time postulated). Smaller, curved nautiloids do not contain cameral deposits and apparently did live in a somewhat vertical position.

As stated previously, the siphuncle is the most important nautiloid feature. The functions of the inner siphuncle structures in the living animal are difficult to interpret because they have no analogies in modern cephalopods. The siphuncle of the living Nautilus is used for removing the cameral fluid from the camerae in order to maintain neutral buoyancy as the animal grows. Ancient nautiloids undoubtedly used the siphuncle, in part, for a similar function. However, many of these siphuncles are much larger than that of Nautilus and contain many structures and deposits that have no parallel in the modern animal. Theorized functions range from reproduction to secretion of cameral and siphonal deposits.

The structures of the outer siphuncle consist of the septal necks, extensions of the septa that bend away from the aperture, and the connecting rings, cylindrical or ring-shaped sheaths extending between two successive septal necks. The various combinations of curvatures of the necks and shapes of the rings are used, along with the types of siphuncular deposits, extensively in the classification and identification of nautiloid genera and species.

A much more detailed discussion of nautiloid morphology is available in the Treatise Part K or in Flower, 1964.

Identification Using the septal necks and connecting rings for identification unfortunately requires sectioning the conch which many are unable or unwilling to do. However, reasonable

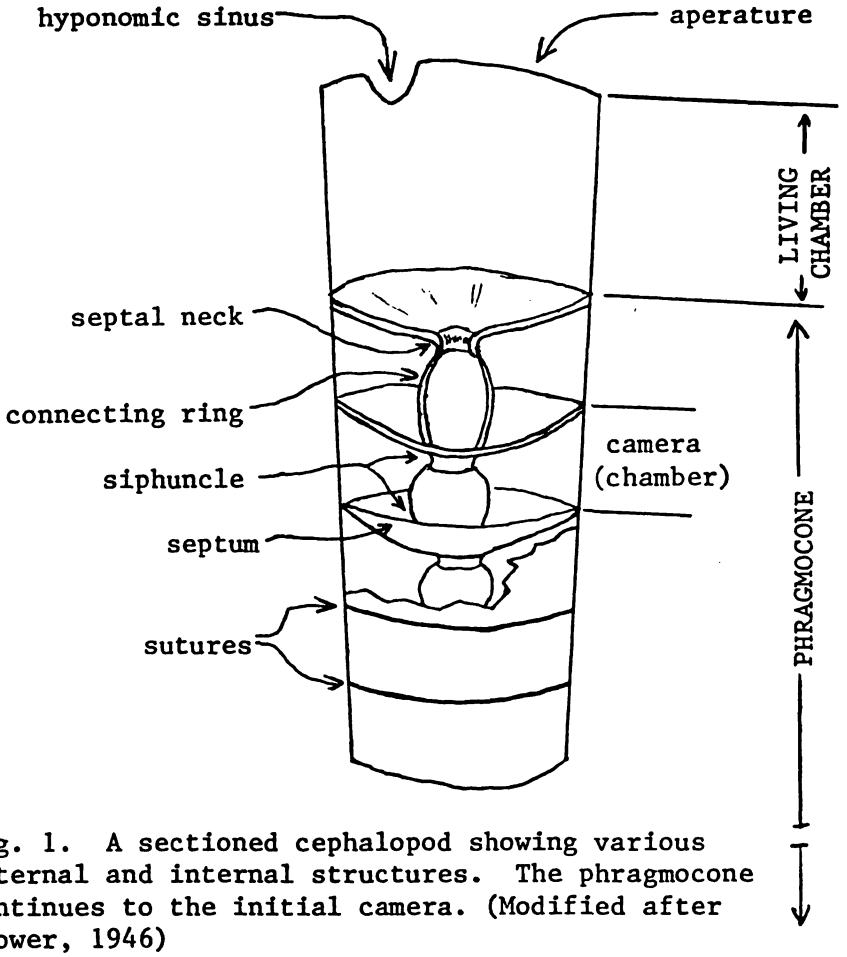

Fig. 1. A sectioned cephalopod showing various external and internal structures. The phragmocone continues to the initial camera. (Modified after Flower, 1946)

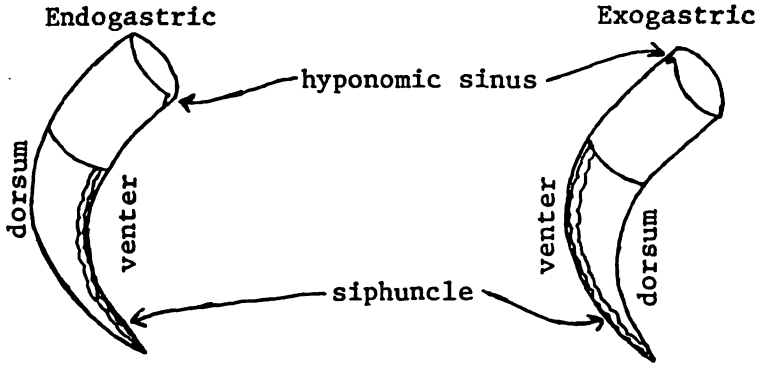

Fig. 2. The position of the siphuncle determines the nature of the curvature and, in the absence of a presrved hyponomic sinus, the ventral side.

identifications can be made on the conch form alone. Early workers, such as Foerste, classified and identified the nautiloids based on form-genera, many of which have stood the test of detailed study and are still considered valid.

Except for some specialized forms, tentative identifications involve the following elements:

1. conch design (straight, curved or coilded)
2. cross section (circular, depressed or compressed),
3. position of the siphuncle (central or ventral),
4. if curved, type of curvature (endogastric or exogastric), and
5. relative size (somewhat subjective).

A cross section that is depressed has a shorter dorsal-ventral diameter than lateral diameter. Fig 1 illustrates the two types of curvature. Assuming two conchs to be oriented the same way, the one with the siphuncle nearest to the concave side is endogastric and the one with the siphuncle nearest to the convex side is exogastric. Since most fossils of nautiloids found are fragments and not the entire conch, relative size must be an evaluation based on both the length and the diameter of the fragment. Very large diameter fragments represent individuals of several meters total length even though the fragment found may only be centimeters in length.

Coiled forms represent one of the less common types in the Platteville fauna and as such are relatively easy to identify when encountered. They are represented, so far, only by the Barrandeocerida (M.Ord-M.Dev). Coiled forms also occur in the Tarphycerida (L.Ord-U.Sil) but are not represented in the Platteville, in the Oncocerida (M.Ord-Miss) but the coiled forms of this order did not evolve until the Silurian and in the Nautilida (L.Dev-Rec) which did not evolve until the Devonian. The coiled forms of large diameter (15-20cm) fall into two genera both of which have siphuncles located near the venter. Plectoceras species are slightly compressed and have transverse ridges that angle away from the living chamber as they cross the venter. Chidleyenoceras species are somewhat depressed, lack ridges and have sutures that display deep ventral lobes. The most common coiled form of the Platteville is the small (6-7 cm) Plectoceras robertsoni which has the transvers ridges of the larger species but is very slightly depressed and has the siphuncle nearly exposed on the venter.

Conchs with endogastric curvature represent a very rare form. Both examples are small (4 cm or so) and are the only representatives of their orders that I have found in the Platteville. The compressed form with the large siphuncle exposed along the venter, called Cyrtocerina, represents the most ancient order, the Ellesmerocerida (U.Camb-M.Dev). The depressed form with the siphuncle located between the venter and the center is known as Ulrichoceras and represents the Discosorida (M.Ord-m.Dev).

Straight shelled nautiloids are among the most common and are represented by four different orders one of which, the Intejocerida (L.Ord-M.Ord),is not represented in the Platteville. Medium to very large (up to several meters), circular, compressed or depressed conchs with large ventral siphuncles belong to the Endocerida (L.Ord-U.Ord). Two genera dominate the Platteville fauna with several more smaller ones to be published.

Endoceras is the most common and has one of the largest siphuncles compared to conch size of any nautiloid. Many conch types have been "dumped" in this genus and much work needs to be done to clean it up probably resulting in the formation of several new genera. Cameroceras is similar to Endoceras except for a generally smaller siphuncle that is exposed along the venter. Several specimens of Cameroceras have been found with variable spacing of the septa in regular patterns suggesting some type of migration cycle. Small to medium sized, circular conchs with small central siphuncles usually belong to the Orthocerida (L.Ord-Trias). There are many genera and species in this order and many times distinction depends on internal characteristics. However, most medium sized, smooth conchs are of the genus Michelinoceras (which also needs much work to clean up) while Gorbyoceras contains most conchs with strong circular ridges (annulations) between sutures. Medium to large conchs with an early (posterior) circular cross section that becomes depressed near maturity

and with a ventral siphuncle that usually decreases in diameter toward the living chamber belong to the genus Actinoceras, a relatively common member (with several species represented) of the Actinocerida (M.Ord-Penn).

By far the most common cephalopod type found in the Platteville rocks is the small, slightly to strongly curved, mostly compressed, exogastric conchs with siphuncles located at the venter that belong to the order Oncocerida (M.Ord-Miss). There are many genera and species but three genera dominate the fauna. Relatively long, highly compressed conchs belong to the genus Richardsonoceras while shorter, only slightly compressed and slightly curved conchs belong to the genus Beloitoceras. Strongly curved, circular to very slightly depressed conchs belong to the genus Zitteloceras.

The above discussion of the Oncocerida brings up an excellent example of how one can recognize an unpublished fossil. For years, I had been finding specimens of a curved compressed form that looked very much like Richardsonoceras except the siphuncle was located near the center, instead of the venter, but which still displayed exogastric curvature. Neither the Treatise volume of published genera nor Foerste's papers on specific cephalopods of the Black River Group (Platteville equivalent) were any help in identifying these specimens. They did, however, appear similar to much smaller circular to compressed conchs of the genus Centrocyrtoceras of the order Barrandeocerida. When I visited Rosseau Flower in New Mexico for the first time and showed him the specimens in question he indicated that they were the same as specimens collected by the late Bill Bode (who gave them to Rousseau) and that they represented a new genus, Magnolioceras, and did indeed belong to the Barrandeocerida. Since then we have identified two distinct species belonging to this genus, one from Bode's collection and one from mine. Upon sectioning several fragments the distinction between this new genus and Richardsonoceras was obvious. Richardsonoceras has expanded siphuncle segments with recurved necks while the siphuncle of Magnolioceras is tubular with simple bent necks.

Finally, there are those forms that are so unique and distinctive that they cannot be confused with any other form. One, a slightly curved and exogastric form, has, when mature, a blunt posterior end, less than 6 camerae (with decreasing septal spacing which indicates full maturity) and a very small siphuncle. This form represents the Ascocerida (M.Ord-Sil), a rare order whose members truncate (drop off) their immature posterior conchs as a method of attaining neutral buoyancy. They are represented in the Platteville by so far unpublished genera (at least three) and species. Another form is probably the most distinctive nautiloid so far known. It is a representative of the Actinocerida and has been named Gonioceras. The conch is very strongly depressed with a flat venter, domed dorsum, lateral "wings" and displays sutures that curve several times forming deep ventral and dorsal lobes and lateral saddles. This is a prized find and is actually not that uncommon.

This short discussion on identification should indicate that a first approximation of genera is not that involved, at least for cephalopods. Most forms differ enough so that confusion is kept to a minimum. As with other fossil groups, species identification is another matter entirely. The Treatise volume describes only to the generic level and specific identification requires a search of the literature to find the original description papers. This has been made easier for Ordovician cephalopods since the great majority of the work has been done by only two authors: Foerste and Flower.

The brief bibliography (next page) that follows gives a variety of papers from basic ones on morphology to specific ones on identification to recent ones on research. For a comprehensive list of references (up to 1964) see the Treatise part K.

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AMMONOID Tornoceras IN THE CEDAR VALLEY LIMESTONE (Middle Devonian)

-- Bob Harris
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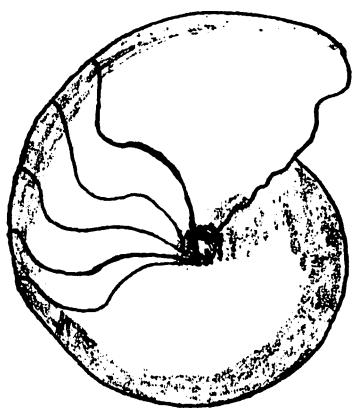
A field trip to a local quarry over the Thanksgiving holiday produced several large anutiloid cephalopods and one small ammonoid. Upon returning to Iowa City I took the specimens to the University Geology Department for help in identification. Professor Brian F. Glenister identified the ammonoid as Tornoceras (Tornoceras) iowaense. He made many helpful suggestions for this paper and pointed out many of the references cited below. The specimen has been donated to the University collection (S.U.I. 51470).

Introduction Ammonoids from the Devonian of Iowa are rare. Three genera have been reported from the Upper Devonian, including Ponticeras from the Independence Shale (Probably a juvenile Manticoceras, Glenister, 1958), Manticoceras from the Lime Creek, and Tornoceras from the Upper Devonian near Amana (Miller, 1938). The Middle Devonian has previously yielded only two specimens of a single goniatite, Tornoceras (Tornoceras) iowaense from the Cedar Valley Limestone (Miller, 1938).

The present paper describes a third specimen of T. (T.) iowaense. It is compared with the previous two specimens and similar Givetian (U.M.Dev) species for evidence bearing on the validity of the species. Finally, the fossil record of Family Tornoceratidae is reviewed for what it might reveal about possible modes of evolution within this group of early ammonoids.



Tornoceras (Tornoceras) iowaense xl
(Redrawn from Miller, 1936, Plate 1, figure 14)

Phylogeny And Occurrence The fossil record of Subclass Ammonoidea began in the Siegenian (L.Dev) with Order Anarcestida. Representatives of Order Goniatitida first appear in Europe during Eifelian time (L.M.Dev) but were represented throughout the entire Middle Devonian by a single family, the Tornoceratidae. House (1981) recognized eleven genera within the family. These few early Tornoceratids were apparently ancestral to all later goniatites.

The nominate genus, Tornoceras, ranged from the Eifelian (L.M.Dev) to Lower Famennian (L.U.Dev) of North America, Asia, Europe, North Africa, and Western Australia. In North America Tornoceras was the longest ranged genus in Family Tornoceratidae, occurring from the Lower Givetian (U.M.Dev) to the Lower Famennian (U.U.Dev) (House, 1965). It was widespread (but sporadic in occurrence) with species reported from New York, Ontario, Pennsylvania, Virginia, Indiana, Michigan, Montana, and Iowa.

Locality And Stratigraphy The new specimen (S.U.I. 51470) was collected from float in the Steve Miller Quarry near Independence Iowa (center of N. line, sec. 14, T. 88 N., R. 9 W., Buchanan County). This quarry exposes the Davenport Member of the Wapsipinicon Formation at its base and the Solon Member of the Cedar Valley Formation above. The ammonoid was clearly derived from the buff-tan calcarenite of the Solon Member.

Evaluation of conodont biostratigraphy in a quarry 1½ miles to the north has placed the Solon Member in this vicinity in the P. varcus zone of the Givetian Stage of the Middle Devonian (Anderson, 1984).

The two previous specimens of T. (T.) iowaense were also collected from the Cedar Valley Limestone in the same general vicinity.

Methods And Materials The following specimens from The University of Iowa Repository were examined:

S.U.I. 731 (Holotype) T. (T.) iowaense Miller, Cedar Valley Limestone, Linn Co., Iowa, Upper Givetian.

S.U.I. 732 (Hypotype) T. (T.) iowaense Miller, Cedar Valley Limestone, "Station No. 168-2" Upper Givetian.

S.U.I. 51469 Tornoceras sp., Alpena Limestone, Alpena, Michigan, Upper Givetian.

S.U.I. 33407 T. (T.) uniangulare Conrad, near Amana, Iowa, Upper Frasnian.

S.U.I. 4722B T. cf. T. (T.) eberlei Sweet and Miller, Columbus Limestone, Dublin, Ohio, Upper Eifelian.

S.U.I. 51467 T. (Parodoceras) discoideum Hall, Marcellus Formation, Cherry Valley Member, S. W. Virginia, Lower Givetian.

S.U.I. 34 T. simplex von Buch, Stringocephalus Limestone, Westphalia Germany, Givetian.

Two species not contained in the University Collection were studied from published descriptions:

T. (T.) mithras (Hall), Columbus Limestone, Columbus, Ohio, Upper Eifelian.

T. (T.) arkonense (House), Arkona Shale, Ontario Ohio, and New York, Upper Givetian.

House (1962) considered T. (T.) eberlei and T. (T.) mithrax as members of anarcestid genus Foordites. They were included here for consideration as geographically proximate members of Tornoceras. T. (T.) uniangulare, though Upper Devonian age, was included since it is the only other tornoceratid species from Iowa.

Systematic Paleontology

Class CEPHALOPODA Leach, 1817
Subclass AMMONOIDEA Zittel, 1884
Order GONIATITIDA Hyatt, 1884
Suborder TORNOCERATINA Wedekind, 1917
Superfamily TORNOCERATACEA Arthaber, 1911
Family TORNOCERATIDAE Arthaber, 1911
Genus TORNOCERAS Hyatt, 1883
TORNOCERAS (TORNOCERAS) IOWAENSE Miller, 1938

Description The new specimen compares well with Miller's original diagnosis. It is an internal mold, badly eroded of the venter and much of one lateral face. The conch is sublenticular and ammoniticonic. It has no visible growth lines. Specimen dimensions are: width 19 mm, maximum diameter 51 mm, whorl height 32 mm, dorsal impressed area 19 mm. The venter is angular in one small undamaged area. Whorls are compressed but broadly convex. Traces of six septa are discernable

of the aboral half of the outer volution. The adoral half apparently represents the living chamber, the poor preservation makes septal location difficult to detect. The sutures that are visible reveal a small ventrolateral saddle, followed by the first lateral lobe extending to the umbilicus. Suture detail on the venter is not preserved. Internal sutures were not determined.

Results And Comparison The holotype (S.U.I. 731) is nearly identical with the new specimen in size, form, and suture pattern. One lateral face has been ground off making it difficult to accurately determine width or the shape of the venter. The hypotype (S.U.I. 732) is smaller than the other two specimens, though overall form is comparable. Due to poor preservation, the suture pattern is not visible dorsal to the adventitious lobe. The venter on this specimen is narrowly rounded.

Considered as a group, the other specimens examined (excluding T. (Parodoceras) discoideum differ only in degree from T. (T.) iowaense. The shell form and suture pattern are very similar in all species, with only slight differences in detail. The specimens do show a wide range in size, with maximum diameters ranging from 5 mm for Tornoceras uniangulare (S.U.I. 33407) to 90 mm for T. (T.) mithrax. T. cf. T. (T.) eberlei (S.U.I. 4722B) is distinguished by a pair of shallow sulci on the ventrolateral flanks. In other respects it is typical of the group.

T. (Parodoceras) discoideum (S.U.I. 51467), a lower Givetian tornoceratid, is clearly distinct from all the other species considered here. It is much less laterally compressed, with whorl width equal to whorl height. The suture has a much reduced ventrolateral saddle and first adventitious lobe, with barely detectable aboral/adoral deflection until the first lateral saddle. House (1965) considered this species as the ancestral form linking the anarcestids to Tornoceras in the lower Givetian.

Conclusions Is Tornoceras (Tornoceras) iowanse a valid species? When compared with the species examined here, it appears unlikely. The overall size, form, and suture pattern are very similar in most of the specimens examined. Most of the differences noted in any one character could easily result from intraspecies variation in a polytypic species. T. (T.) mithrax and T. cf. T. (T.) eberlei are probably distinct chronospecies, however, since they were separated so far in time from T. (T.) iowaense (assuming correct and independent correlation of the respective beds).

Miller (1938) cited the subangular venter as one feature which distinguished T. (T.) iowaense from all congeneric species. But the shape of the venter is difficult to assess in the three known specimens. The new specimen has one small section where the venter does appear subangular. The holotype has been ground down destroying much of the venter. The hypotype has a venter which appears narrowly rounded, but preservation is poor, and the present shape may not reflect the original form.

Limited sample size is another factor which makes species designation difficult for T. (T.) iowaense. With only three specimens available to study, no valid conclusions can be made regarding intraspecies variation or clinal gradients with other species. The same situation exists for many other members of the genus, where limited material makes species diagnosis uncertain.

In broad overview, the specimens examined here and described elsewhere present a picture of remarkable stability. For a group that persisted over 20 million years, the Tornoceratidae demonstrate a very conservative evolutionary history. T. (T.) uniangulare, by far the most long-ranged, abundant, and widespread of tornoceratid species, reveals a graded variation in nearly all characters (miller, 1938). Yet throughout its entire range this species shows very few distinct or continued evolutionary trends (House, 1965). The basic suture pattern and conch form are the same in both lower Givetian and upper Frasnian forms.

It was probably from this persistent T. (T.) uniangulare root stock that small, isolated groups occasionally branched off. T. (T.) iowaense was an example of these geographically isolated and low abundance groups.

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COLLECTING DEVONIAN AMMONOIDS FROM NEW YORK

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Ammonoids existed over a time span of about 320 million years from their first appearance in the early Devonian until their extinction at the close of the Cretaceous. Their origin has not been resolved without question but ammonoids appear to have been derived from an ancestral bactritid stock which, in turn, evolved from an orthoconic nautiloid.

In 1957 the Treatise on Invertebrate Paleontology on ammonoids covered 77 described Devonian ammonoid genera. By 1984 the number of described genera had increased to 155 indicating a dramatic amount of research (House and Senior, 1981). The Devonian is the time period with the fewest ammoinoid genera (205 for Carboniferous, 460 for Triassic, over 850 for Cretaceous, (House and Senior, 1981). Europe has the largest number of described genera (120), while South America has only one. In eastern North America there are 37 genera, 29 of these can be found in New York. Of the remaining genera, six are from the Upper Devonian of NE Ohio and NW Pennsylvania, and two from the Middle Devonian of Virginia.

During the Devonian a wide variety of ammonoids occurred and, because the group almost became extinct at the close of the period, the Devonian ammonoids represents a particularly distinct aspect of the group. Of the seven orders of ammonoids, two (Anarcestida and Clymeniida) are restricted to the Devonian and a third order (Goniatitida) begins in the Devonian and ends at the close of the Permian. These three orders include half of the 14 suborders of the Ammonoidea recognized to occur in the Devonian (House and Senior, 1981). The Anarcestida (4 suborders) are the first to appear in the Lower Devonian but became extinct at the close of the Devonian. In the Middle Devonian the first Goniatitida (one suborder) appeared with just 3 genera, proliferated in the Upper Devonian with 31 genera and then having only three genera crossing the Devonian-Carboniferous boundary to give rise to

all post Devonian ammonoids. In the late Devonian the Clymeniida (2 suborders) are characterized by a dorsal siphuncle (all other groups have a ventral siphuncle). The origin of this peculiar group has been debated but not resolved. However, because they evolved so rapidly over such a short time interval, they have become excellent index fossils.

Because New York has one of the best sequences of Devonian rocks to be found anywhere in the world, it has become very important in verifying the ammonoid zones established in Europe from widely scattered localities. It has been shown by ammonoid workers that the collecting of specimens from New York with detailed stratigraphic and geographic data is important in resolving the distribution of genera and ammonoid zones. A simplified version of the distribution of the 29 genera of New York is shown in Figure 1.

The exquisite preservation of New York ammonoids has made them very important for ontogenetic and phylogenetic studies. Modes of preservation include: pyritic internal molds (steinkerns); internal molds of limestone from limestone beds; shells replaced by barite; and shells replaced by calcite.

Over the years I have collected 14 genera in New York including many described and undescribed species. Below is a brief review of their distribution and some personal collecting experiences.

The oldest ammonoids to be found in New York are from rocks that are late Early Devonian (Emsian) in age. Only two species are known, Convoluticeras (?) and Anarcestes. Each is described from a single, poorly preserved specimen and the identification of each ammonoid is not absolutely certain.

In the early Middle Devonian (Eifelian) of New York, only one ammonoid has been discovered, Foodites from Onondaga Limestone. Eifelian age rocks of New York are not productive when compared to the same age rocks of Europe and North Africa where many ammonoids have been described. This may be due to the lack of collecting, nonpreservation or absence of ammonoids. Yet, the Columbus Limestone of Ohio is Eifelian and has yielded four species (Sweet and Miller, 1956).

In the late Middle Devonian (Givetian) rocks of New York, the diversity of ammonoids increases but still is not as great as it is in Europe and North Africa. I have collected all the described species (10 species) of Givetian ammonoids of New York and have found many undescribed species.

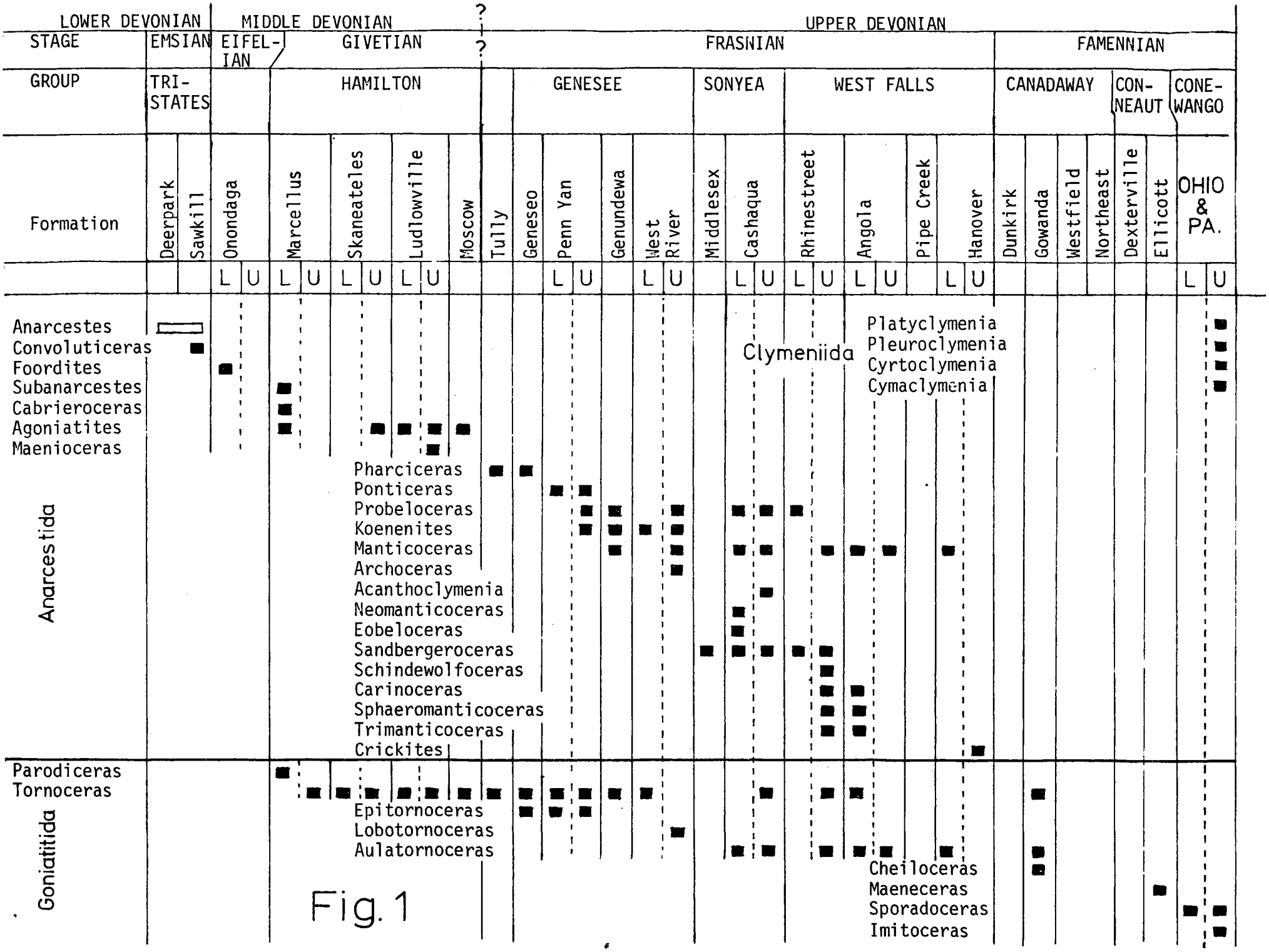
Cabrieroceras plebeiform (Figure 2), common in the Union Springs Shale Member of the Marcellus formation, is a "fat" ammonoid with a large open umbilicus. Most specimens are 2 or 3 inches in diameter but can get up to 5 inches. Specimens are preserved in concretions as internal molds of the body chamber or the shell can be replaced by calcite. Sometimes an external mold can be found on the bottom of the concretion. When a latex cast is made from the mold, one can observe details of the growth lines and the lateral nodes that are on the shell.

Subanarcestes is also described from the Union Springs Shale and is found in a thin (3 or 4 inch) limestone bed. It is not very common and because specimens are poorly preserved, more material is needed to adequately describe this form.

The Union Springs Member is a black calcareous shale that quickly weathers. When digging out concretions from the shale, one can not avoid getting filthy and looking like a chimney sweep after a day's collecting in this unit.

In the Cherry Valley Limestone of the Marcellus Formation, Agoniatites and Parodiceras occur. Because Agoniatites is so abundant, the Cherry Valley Limestone was once referred to as the "Goniatite" or "agoniatites" limestone. Although Agoniatites is abundant, specimens are difficult to collect. The Cherry Valley is a massive, 4 foot thick, black limestone. Unweathered blocks of limestone do not easily yield specimens. Only when the rock is weathered can pry bars, sledge hammers and chisels be used to work out specimens. Some of these specimens can have a diameter of 13 inches, making Agoniatites the largest Middle Devonian ammonoid in New York. These large specimens are very difficult to collect whole as they break easily. Therefore, specimens have to be removed in large blocks and it is not unusual for me to bring back over 300 pounds of rock from the field.

From the Cherry Valley Limestone three species of Agoniatites have been described, A. floweri A. intermedius and A. vanuxemi, the type species of Agoniatites. Agoniatites has a


LOWER DEVONIAN
MIDDLE DEVONIAN
UPPER DEVONIAN
STAGE
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EIFEL-IAN
GIVETIAN
FRASNIAN
FAMENNIAN
GROUP
TRI-STATES
HAMILTON
GENESEE
SONYEA
WEST FALLS
CANADAWAY
CON-NEAUT
CONE-WANGO
Formation
Deerpark
Sawkill
Onondaga
Marcellus
Skaneateles
Ludlowville
Moscow
Tully
Geneseo
Penn Yan
Genundewa
West River
Middlesex
Cashaqua
Rhinestreet
Angola
Pipe Creek
Hanover
Dunkirk
Gowanda
Westfield
Northeast
Dexterville
Ellicott
OHIO & PA.
L U
Anarcestes
Convoluticeras
Foordites
Subanarcestes
Cabrieroceras
Agoniatites
Maenioceras
Pharciceras
Ponticeras
Probeloceras
Koenenites
Manticoceras
Archoceras
Acanthoclymenia
Neomanticoceras
Eobeloceras
Sandbergeroceras
Schindewolfoceras
Carinoceras
Sphaeromanticoceras
Trimanticoceras
Crickites
Clymeniida
Platyclymenia
Pleuroclymenia
Cyrtoclymenia
Cymaclymenia
Anarcestida
Parodiceras
Tornoceras
Epitornoceras
Lobotornoceras
Aulatornoceras
Cheiloceras
Maeneceras
Sporadoceras
Imitoceras
Goniatitida

Fig. 1

simple suture, yet, there is a great amount of confusion about the three species and the diagnostic characters of the genus. The three described species are based on the presence or lack of nodes and spines, however, I have observed at least seven different forms. I have collected over 130 specimens of Agoniatites and with these specimens I hope to clear up much of the confusion. I have often wondered, if there is so much confusion over a simple ammonoid, what is being done with the more complex ammonoid species?

The most common ammonoid to be found in the Hamilton shales is Tornoceras (Fig. 2); this is also the only genus to be found in both Middle and Upper Devonian rocks of New York (Fig. 1). There are eleven described species from New York. The most common and most sought after by local collectors are the beautifully pyritized specimens of Tornoceras uniangulare. On rare occasions, these can be over 2 inches in diameter.

In the Ludlowville Formation, a 10 foot interval has yielded pyritized specimens of Agoniatites unilobatus, undescribed species Tornoceras and Maenioceras and an undescribed tornoceratid. This interval is significant, as it is the only horizon where Maenioceras, an important index fossil for the Givetian, has been found in New York. It belongs to a new species, which I would like to describe. Unfortunately it is very rare and I may never get enough material to adequately describe it. Over the past 10 years only three specimens have been found and I know of no others. This small number of specimens is not due to a lack of collecting. This species of Maenioceras is the shape and size of a cherry pit and is easy to spot. Such was the case when the first specimen was found on a weathered slope. Further specimens were found by washing the weathered shale on a screen. The mud is removed leaving the pyritized fossils behind. This method has been very productive in collecting pyritized fossils, including over 1400 small Tornoceras. Yet, only 2 Maenioceras have been found this way.

In the early Upper Devonian (Frasnian) the diversity of New York ammonoids increases considerably and becomes very similar to the European and North African ammonoid fauna. This increased similarity has been interpreted by many paleontologists as a dramatic increase in migration between eastern America and Europe. Although there are many Frasnian genera in New York (Fig. 1), I will just refer to those I have collected.

Probeloceras (Fig. 2) is a laterally compressed widely umbilicated ammonoid that can exceed two inches in diameter. The Best specimens come from concretions in the Cashaqua Shale (see below).

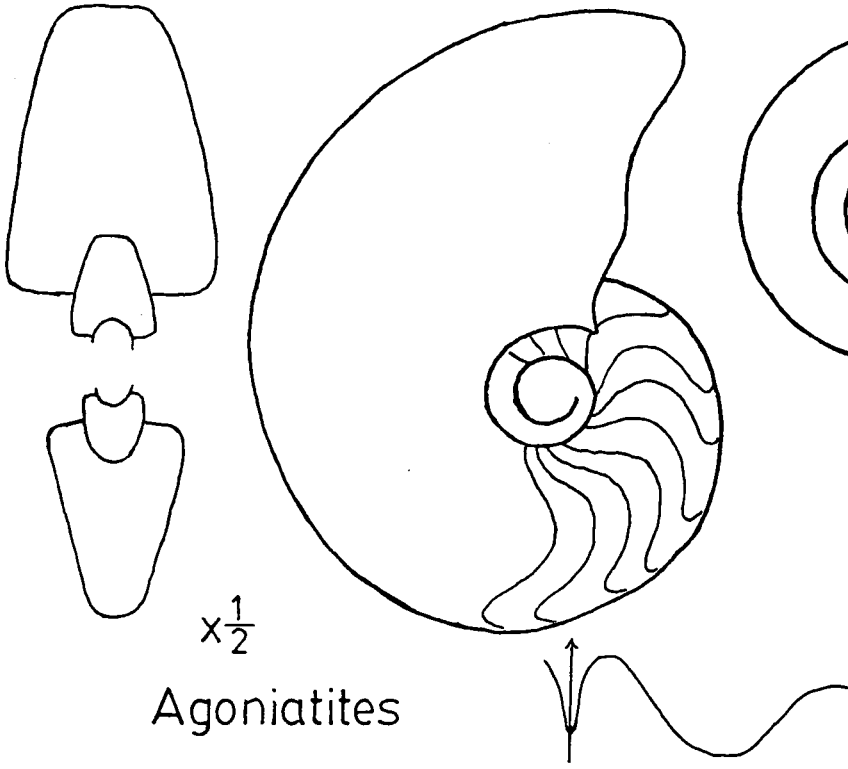
Manticoceras (Fig. 2) is the most common Frasnian ammonoid, ranging from the Genundewa Limestone to the Hanover Shale. In New York there are nine described species. In the Cashaqua Shale some specimens of M. sinuosum (also Probeloceras and Tornoceras) occur as baritic replacements in limestone concretions. When they are removed from the matrix with acid, specimens are delicate and beautifully preserved.

In the Hanover Shale small (less than 1/4 inch) specimens of M. cataphractum and Aulatornoceras are found together in pyritic clusters. These specimens were commonly broken before they were pyritized. Because of the damage, I have interpreted these clusters as coprolites from an animal that ate small ammonoids.

Sometimes beautifully pyritized specimens of Manticoceras can be found in the Cashaqua and Angola Shale. I have only collected small (less than 1/2 inch) specimens but have seen them up to two inches. In the Buffalo Museum of Science there is a pyritized specimen of Manticiceras, 5 inches in diameter with no data. I have no idea where it came from but, believe me, I am trying to track down the source.

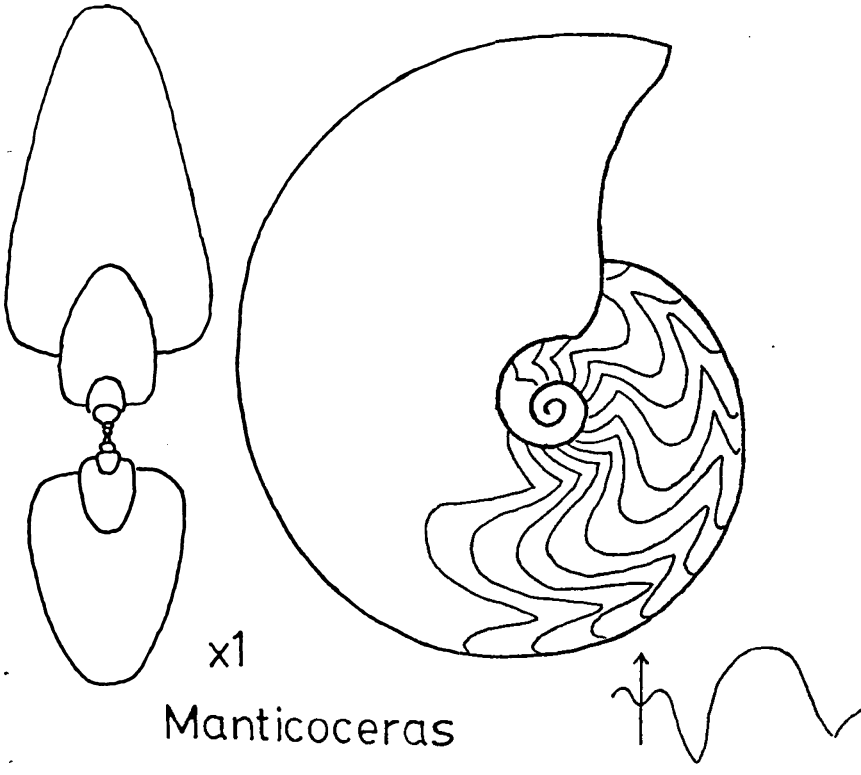
Sphaeromanticoceras rhynchostomum is a beautiful ammonoid from the Angola Shale which is closely related to Manticoceras. Specimens replaced by calcite are found in concretions and can be over 12 inches in diameter making it the largest Upper Devonian ammonoid in New York. Specimens are difficult to prepare but when the preparation is finished, they prove to be beautifully preserved.

Crickites holzapfeli, also closely related to Manticoceras, is a rare ammonoid in the Hanover Shale. I have two specimens that may belong to this species but the identification is uncertain. One Devonian ammonoid expert referred my specimens to C. holzapfeli and another to M. bullatum. The problem in making an identification is that the type specimens of



x$\frac{1}{2}$

Agoniatites



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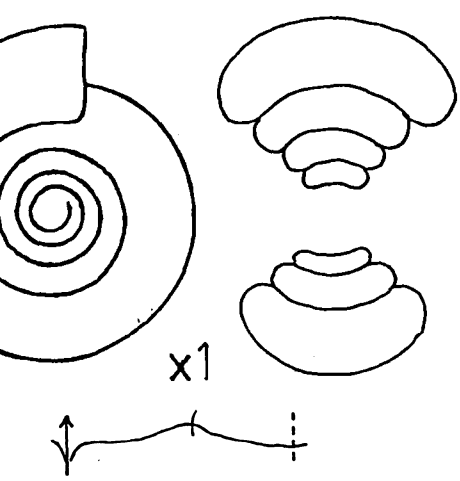
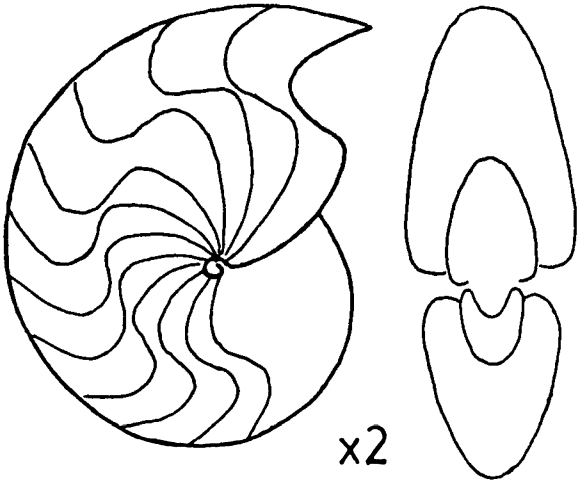
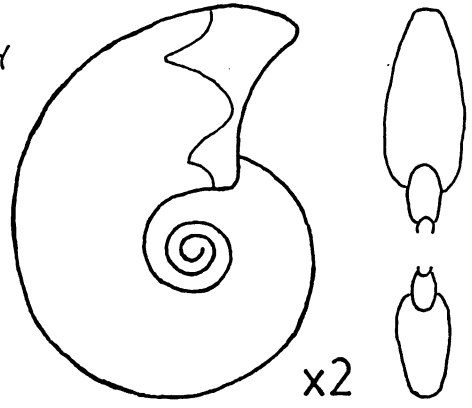
Manticoceras



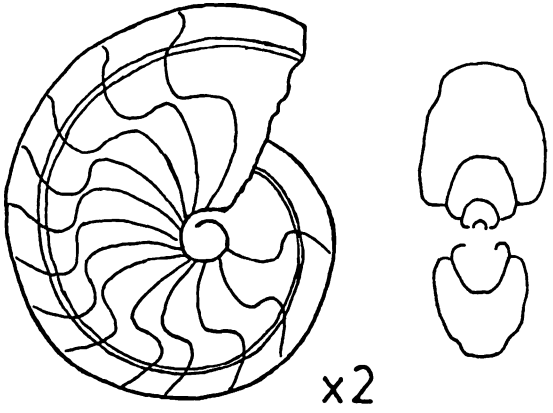
Cabrieroceras



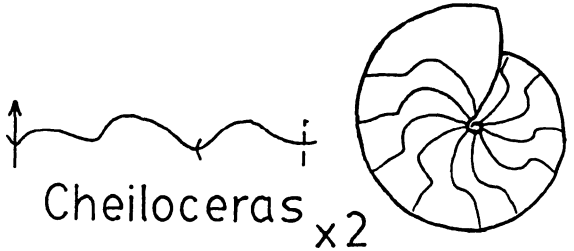
Tornoceras



Probeloceras



Aulatornoceras



Cheiloceras

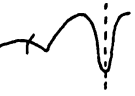


Fig. 2

C. holzapfeli and M. bullatum (both European species) are less than 2 inches in diameter, while my specimens are 6 inches in diameter. Because of the difference in size, comparisons become difficult due to possible ontogenetic changes. This is a very common problem when working with ammonoids and can only be resolved when enough specimens are collected to show ontogenetic changes.

Koenenites can be found in New York rocks but no specimens have been described, as yet. Currently Dr. Kirchgasser is working with these specimens and has found at least 6 different species. I have collected specimens of Koenenites but the determination of species will have to wait until Dr. Kirchgasser's work is published.

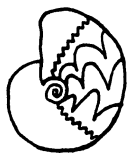
Prior to 1962, only two species of Aulatornoceras had been described from the late Upper Devonian (Famennian) rocks of New York. Since then Dr. House of England has described several ammonoids from this interval. The Gowanda Shale contains a pyritized fauna that includes Cheiloceras amblylobum (Fig. 2), Aulatornoceras bicostatum (Fig. 2) and Tornoceras (T.) concentricum. Also from this horizon I have found an undescribed species of Tornoceras (Linguatornoceras).

The Conneaut and Conewango Groups of New Yok are composed of siltstones and sandstones. These rocks are not favorable for preserving ammonoids. Although specimens of one ammonoid genus (Maeneceras) have been described from these rocks (Fig. 1), they are often preserved as external casts in the siltstones, revealing no sutures, making them difficult to describe. However, to the west in NW Pennsylvania and NE Ohio, the rocks grade into shales where ammonoids have been found and for the first time from eastern North America, ammonoids of the order Clymeniida have been reported.

Because there have been so many new finds of Famennian ammonoids in recent years, especially the Clymeniida, it is obvious that collection failure must be a significant factor in the apparent rarity of ammonoids in this interval in New York. This interval will produce more ammonoids once they are sought after. For example, there are no reported ammonoids from the Northeast Shale (Fig. 1), but I have seen ammonoids from this unit.

Although there has been a lot of work done on the Devonian ammonoids of New York, much remains to be done. More specimens of poorly described species must be collected so that these species can be adequately described. Also, many rock units have not been examined systematically for new ammonoid specimens. Over the years I have enjoyed looking for and collecting New York ammonoids and hope to contribute to a better understanding of these fossils.

As stated before, only one ammonoid has been discovered from the Onondaga Limestone, yet, the Columbus Limestone of the same age has four described species. Therefore, I would like to encourage collectors from Ohio to look for and collect ammonoids from the Columbus Limestone. Because these ammonoids may be important for research, I would like to acquire these specimens by trading or purchase. If any reader has or knows of any ammonoids from the Columbus Limestone, please contact me. When collecting ammonoids from the Columbus Limestone, be sure to get as much detailed stratigraphic data for these specimens, as possible. Then I would hope one would make these specimens available for research rather than burying them in an unlabeled box. This is something I have seen done too often.



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THE SCAPHITES

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When I first moved from the Midwest to Billings, Montana, some eight years ago, I was most familiar with Paleozoic echinoderm fossils. Since Billings is situated within the broad band of Late Cretaceous-age rocks that runs north-south across Montana, it was new terrain and new critters for me! Some of these "new" old critters that have caught and held my attention are the scaphites.

Scaphites, as they are commonly known, are ammonites (Class Cephalopods: Order Ammonoidea) belonging to the Family Scaphitidae. Scaphites are common and characteristic ammonites of the Late Cretaceous. They appear in upper Albian time (98 Million Years BP) and prosper through mid-Maastrichtian time (65 Million Years BP). Scaphites are known from North America, Greenland, Europe and Asia. Representative North American genera include: Clioscaphites, Discoscaphites, Hoploscaphites, Rhaeboceras and Scaphites.

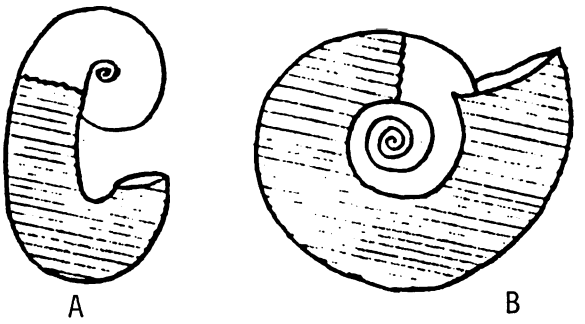

Fig. 1. Comparison of coiling between an adult scaphite (A) and a typically-coiled ammonite (b). Patterned area indicates adult body chamber.

Within the Western Interior of the US, scaphite species tended to be short-lived (600,000-700,000 years is average according to Kennedy & Cobban, 1976), represented by numerous individuals, and geographically widespread. For these reasons, scaphites are ideal index fossils for subdividing Late Cretaceous time. Fourteen ammonite zones within the Late Cretaceous are based upon scaphite species.

Scaphites are often the most common fossil within a particular layer of rock. Abundance of the scaphites is best demonstrated by Waage's (1964) study of the Fox Hills Formation in South Dakota. In one single fossiliferous layer, the scaphite, Hoploscaphites nicolleti, was not only the most abundant ammonite, but also one of the most common fossils. Waage estimated that H. nicolleti occurred in a density of one million individuals per square mile!

The scaphitid ammonites are "heteromorphic"; that is the shell begins to uncoil with the last whorl. Therefore, the shape of the adult shell departs from that of a typical ammonite (see Fig. 1). Since the shape of the shell changes with maturity, it is possible to distinguish an adult from a juvenile. This is not possible with most ammonites having uniform coiling throughout growth.

Being able to recognize adults has several interesting consequences: Most scaphite species occur as two forms. One form is larger and more involute than the other and has an umbilical swelling (Fig. 2). Cobban (1969) has shown that the two forms are actually sexual dimorphs. Presumably the larger form is the female and the smaller more evolute form is the male. In

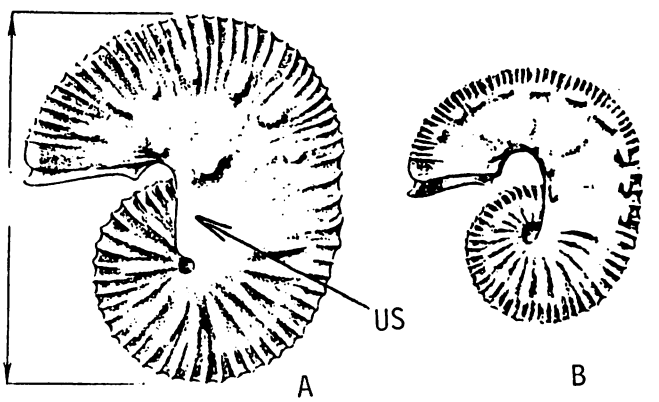

Fig. 2. Drawing of a female (A) and a male (b) Scaphites hippocrepis. L, length of shell; US. unbilical swelling.

the past, some paleontologists mistakenly considered the two forms to be distinct species or at least separate varieties of the same species (Fig. 3). One question that you might ask is "If there are recognizable males and females, what is the ratio of males to females in a population?" Surprisingly, the sexual ratio varies considerably. Some species have been found at a 1:1 ratio; in two populations that I have collected (Cliioscaphites vermiformis and Hoploscaphites nodosus), females are much more abundant than males; and in some species the sexes are generally separate.

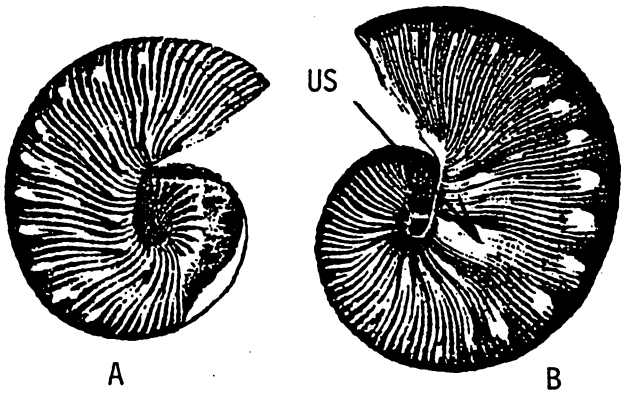

Fig. 3. Hypotype of Hoploscaphites nodosus quadrangularis (Meek & Hayden) = male (A). Holotype of Hoploscaphites nodosus brevis (Meek & Hayden) = female (B).

Large collections of adults of a scaphite species from one locality (representing a population) show a considerable range in size from male to female (Fig. 2, 3). The range in size is such that the largest males are larger than the smallest females, but never get as large as the largest females. Not only is there a size difference between the sexes, but there is also a big range in size within each sex. The ratio of lengths of the largest and smallest adult of each sex is commonly from 1:1.5 to 1:2.5, but the maximum can be 1:4 (Cobban, 1969). The maximum ratio of smallest adult male to largest adult female can be 1:4 to 1:6!

Finally, the interesting thing about scaphites is that they are not simply found by themselves. They are generally part of a diverse mollusk fauna that includes pelecypods, gastropods, nautiloids and other ammonites. How all these critters lived--and died--together is the question with many answers yet to be discovered.

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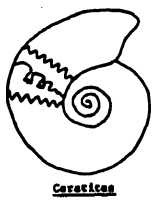

THE FASCINATIN'EST CRITTER

-- Clarence Schuchman
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To stumble upon a vestage of one of nature's creatures protruding from solid rock is to leave an event indelibly imprinted upon one's consciousness. Actually I suppose not many people have the experience. True they are often enough presented with exhibits prepared for them by those who have, but that can never be the same. With this elemental confrontation the enormity of this phenomenon begins to dawn. The mind finds itself teetering on the brink of an eternity of time and space, much as when stepping to the edge of an overlook at the Grand Canyon.

This experience has, no doubt, made incipient collectors or paleontologists out of everyone who has known it. We seem ever thereafter dedicated to tantalizing each other with its imponderables and to passing on full circle the aura of the moment to the rest.

Then we begin to gather up the ferns, or the bones, or the shells, or the "whatever" that is destined to be our "collection". Soon appreciation begins to build for the pattern, the detail, the subtle difference--the fossil story told. We become caught up in a rising tide of enthusiasm for detail--a fervor linking us arm in arm with the artisan, the musician, the artist, indeed with humanity itself which harbors a native core of such appreciation at its heart.

Most of us, through this process, end up centering on our favorite thing, the trilobite, the crinoid, the fish, the leaf, any of hundreds of things circumstance may have brought to hand. The rare professional achieves all-encompasing enthusiasm for the gambit of fossils. Most of us will spend time in any group half-seriously recounting the pursuasions that make our specialty the most intriguing.

To such discussions the ammonoid collector brings an arsenal of pursuasion perhaps impossible to match. (I warned you!)

A collector whose hammer has just split a 'cannon ball' concretion, and whose eye falls upon a golden disk exposed at its center, drops to his knees for a closer look. Expanding into his field of vision, iridescent with merging flashes of golds, ruby, and emerald, come into focus the machine-perfect details of a Placenticeras or a keeled Hauericeras. An even closer look discloses hints of the intricate fern-like suture structures half-hidden beneath the translucent shell.

Here you no longer have a collector, you have an ammonoid evangelist. This creature, veiled in the mysteries of extinction, offspring of the marriage of mathematics and art, has certainly to be at the apex of the experience of 'creature in the rock' and has just 'captured' the creature who exposed it

The versitility of shapes and configurations assumed by the ammonoid seem inexhaustable. From the smooth disk-shaped planispirals (oxicones) we have just mentioned to their opposite numbers, the squat spirals with conical sides like croquignole rings (cadicones). From the rope-coiled lytocerids (evolute serpenticones) to the phyllocerids whose outer whorl covers the inner ones (involute oxycones), the mathematical possibilities of spiral design are completely exploited by this inventive mollusk.

Highly sculptured and ribbed forms abound, often exquisitly beautiful as is Oxitropodoceras and Dipoloceras. There are shells ornamented with nodes and spines as Douvilleiceras or Chelloniceras. Some come decorated with crinkly flairs--the variety is endless.

As if this were not enough, other ammonoids departed the ordered world of planispiral design and launched out into loosely coiled patterns, 'ringing out changes' on variations of corkscrews, hooks, and loops, as in Bostrychoseras, Crioceras, and Pseudhelicoceras. Called heteromorphs in the 'business' the ammonoids explored the forms termed torticonic and helical, not hesitating to continue on into the bizarre and even the half-hideous as in the 'blobbose' Niponites.

Size variations are enough to test the versitility of any collector. The initial whorls of Baculites require microscope techniques, as do the protoconchs (original stage) of many larger forms. But what follows is sufficient to lure

the devotee of the microfossil from his stuffy cubicle to shed his crutches of microscopy in exhilarating pursuit. For from individuals of less than a millimeter the ammonoid ascends to huge giants 3 meters in diameter. Collectors seeking to remove a monster Alaskan specimen reportedly talked the Navy into sending out a helicopter which proved inadequate and had to be sent back for reinforcements.

Whence came they, these versatile creatures who populated the seas for hundreds of millions of years? The Molluscs (phylum to which the ammonoids belong) early in the Cambrian placed their bets on defense. They built 'forts' of calcium compounds programmed out (sometimes elaborately) by a fleshy mantle that secreted them from sea water. This strategy held the disadvantage of restricting mobility because of the weight and rigidity of the shell--though admittedly it furnished the mollusk a really neat device for digging and burrowing. Larvae of the mollusks floated about as plankton before becoming anchored down with heavy equipment.

This state of affairs continued until the Upper Cambrian when appeared a 'mollusk with imagination', the forerunner of the Cephalopoda. Tired of bottom-bound existence, this forward-thinking creature began sealing off part of its shell as it grew. Each time it 'molted' it left a new hollow chamber partitioned off by a septum.

But it did not completely abandon the old house.

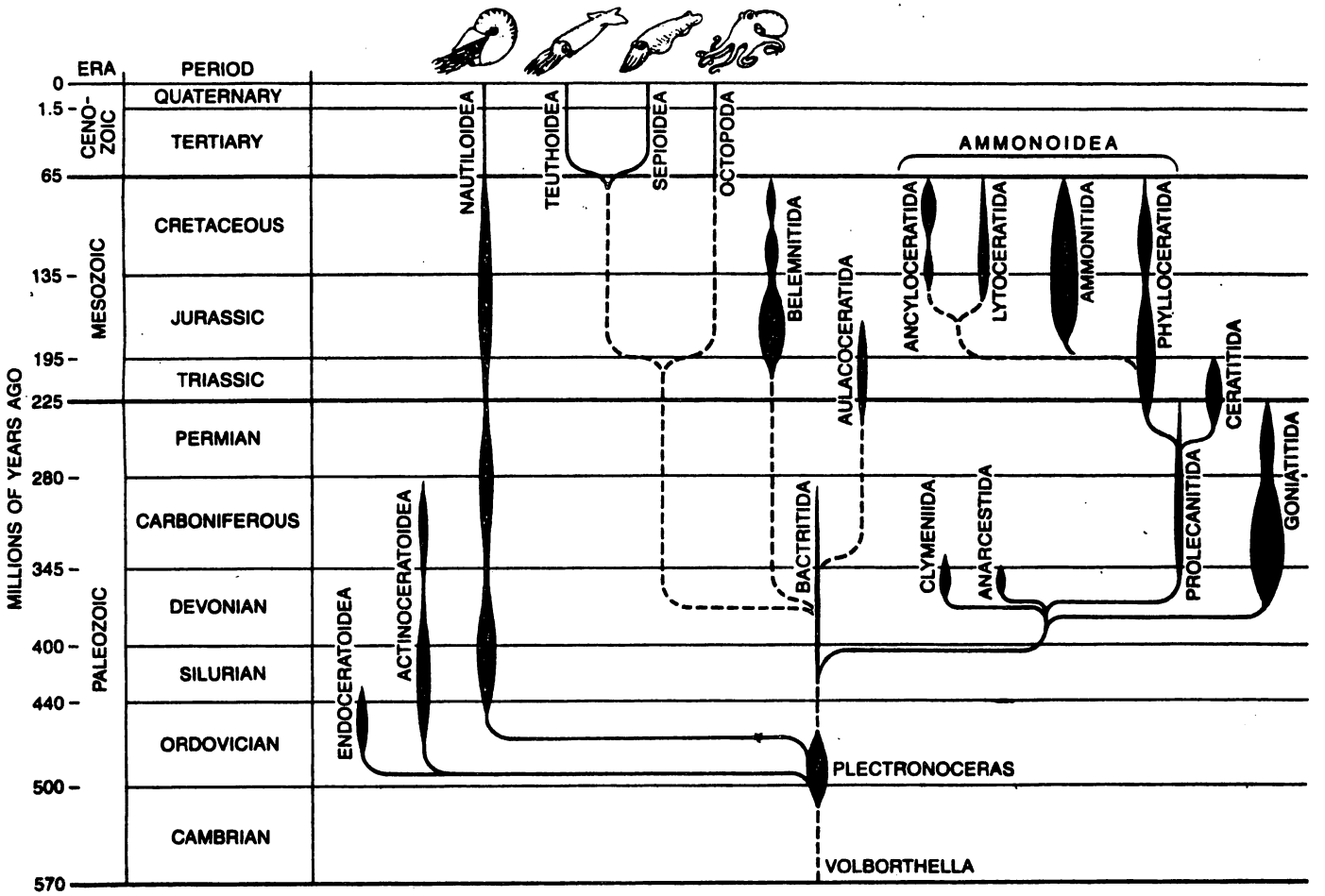


Fig. 1. Small group of nautiloids (ancestors of the modern chambered nautilus) called bactritids may be the common ancestor of extince ammonoids and belemnites and all modern cephalopods--including cuttlefish, squid and octopus. Orthoconic (straight-shelled) bactritids developed into ammonoids when their shells rolled into progressively tighter coils. Belemnites had an internal chambered shell surrounded by a soft body. Modern cephalopods have either a chambered internal shell, a laminated cuttlebone, a 'pen', or in the case of the octopus, a vestigal skeleton consisting of small horny supports or a simple rod. These internal-hard parts are homologues of the external chambered shells of nautiloids and ammonoids.

A tiny living tube was left connecting the old rooms (camerae) with the new. With this 'siphuncle' the animal could remove liquid and add gas (you can't do one without the other) to the camerae.

Now what do we have here? A boat of course! But, not just a boat--a submarine! By delicate adjustments of gas-liquid balance we can move up and down in the water at will. What do we use for oars" Obviously jet propulsion. You squirts water out one way, you moves out the other.

But at first there were no ammonoids (ammonite refers to Mesozoic forms, Fig. 1 shows the complete evolutionary picture). First came certain rudimentary forms, then came Nautilus. Early nautiloids were probably straight, tube-like cones (bactritids), a shell form that disappeared and then, strangely, appeared again among the ammonites just before their final extinction 65 million years ago.

The bactritids occupied conical tubes, sometimes many feet long, separated into chambers by simple curved septa through the middle of which ran the siphuncle. Soon curved cones were found to make a neater package, usually coiled in a planispiral. Nautilus has survived in this form today. Its features are: a rather large larval form, probably not planktonic, a relatively thick shell with simple curved septa, and a centrally located siphuncle.

The ammonoids, which may also have descended from the bactitrids, departed this simple pattern for all kinds of fancy goings on which succeeded enormously well for hundreds of millions of years, but which fancy fling came a cropper in the long run. Except for their incomparable shells they are gone. The Nautilus remains (but only a scant few) today.

The living nautilus, contained in about one-half whorl of his chambered shell, opens his trap door (hood) to disclose two large baleful eyes (they work like pinhole cameras) staring from either side of a bundle of tentacles. He uses these tentacles for a number of things including grasping and dragging along the bottom as feelers. These 'feet' are clustered around his head (cephalopod = head-foot) and feed him through his powerful beak with which he can crunch up such things as crab shells which he thinks a delicacy. Water is circulated in and around the two pairs of fills (tetrabranchiate) and out through the jet propulsion unit (hyponome). Unlike other cephalopods he has no ink cloud into which to disappear nor any suction cups on his tentacles.

Nautilus furnishes virtually our only clues to how the ammonoid animal may have looked. No soft parts have been preserved nor anything verifiable as impressions of them. 'Slow' X-rays reportedly have shown what might be 'shadows' in the rock that could represent them. Once in some matrix I removed from an ammonite (collectors take note), I found a beak that might have belonged to either an ammonite or a nautilus. Numerous ammonite parts called aptychi have been found and studied which may have served the same function as the nautiloid hood, but then again might have been used as plankton gatherers.

To assume that the ammonoid animal resembled the living nautiloid animal just because some of the shells have the configuration of a nautilus shell could also be to fall for one of the neatest decoys of all time.

For example, it boggles the mind to imagine what kind of animal occupied the shell of a Polyptychoceras which resembles nothing quite so much as a contrabassoon. Such forms may also suggest that a Phylloceras conch, which is very similar to Nautilus, might actually have housed a very different sort of creature.

These problems may never be solved. The burden of their solution, if it is to happen, might just rest on the shoulders of you collectors out there. More than anyone else, including the professional, you have the people and the opportunity to observe some slight detail that might unravel the conundrum. Damaged shells particularly afford opportunities for speculation on the manner, the cause, and the contents when broken. Crushed shells, sometimes scorned by the novice, might well provide your best indicators.

Developing through the intermediate stages shown in Fig. 1 the ammonoids evolved several typical differences in shell structure from Nautilus.

First, the protoconch (see Fig. 2), or beginning animal unit, in Nautilus is much larger 15 - 25mm as against 1 mm for some ammonoids. This seems, for one thing, to place the larval ammonoid (particularly the ammonite) in a completely different planktonic life style than Nautilus

Second, some ammonoid shells are much thinner and more delicate than Nautilus. This is made possible in the ammonite with no dimuation of strength by the most intricately engineered internal support structure ever devised by a shelled creature (Fig. 2) It was accomplished by elaborate folding of the septal walls as they approached contact with the outer shell. These folds developed into a 'trunks-to-limbs-to-branches-to-twigs-to-tendrils' structure sequence that upon contact with the outer shell supported every minute area against impossion or explosion due to variation in pressure at depth. Where these structures attached to the outer shell elaborate fern-like external suture patterns were etched characteristic of families of ammonites, and are much used by scholars for identification. This whole fabrication resulted in a strong, feather-light vessel which compares to the nautilus much as an aircraft compares to a tugboat.

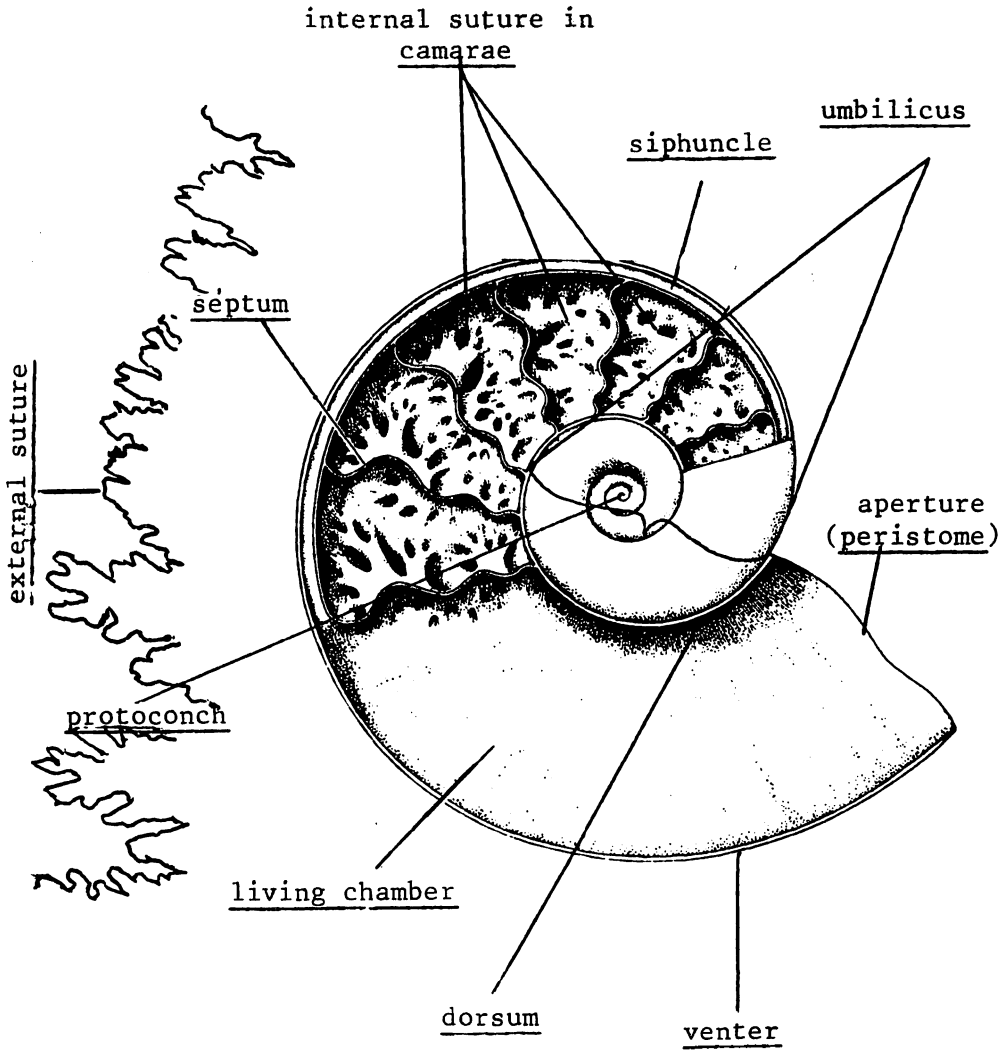
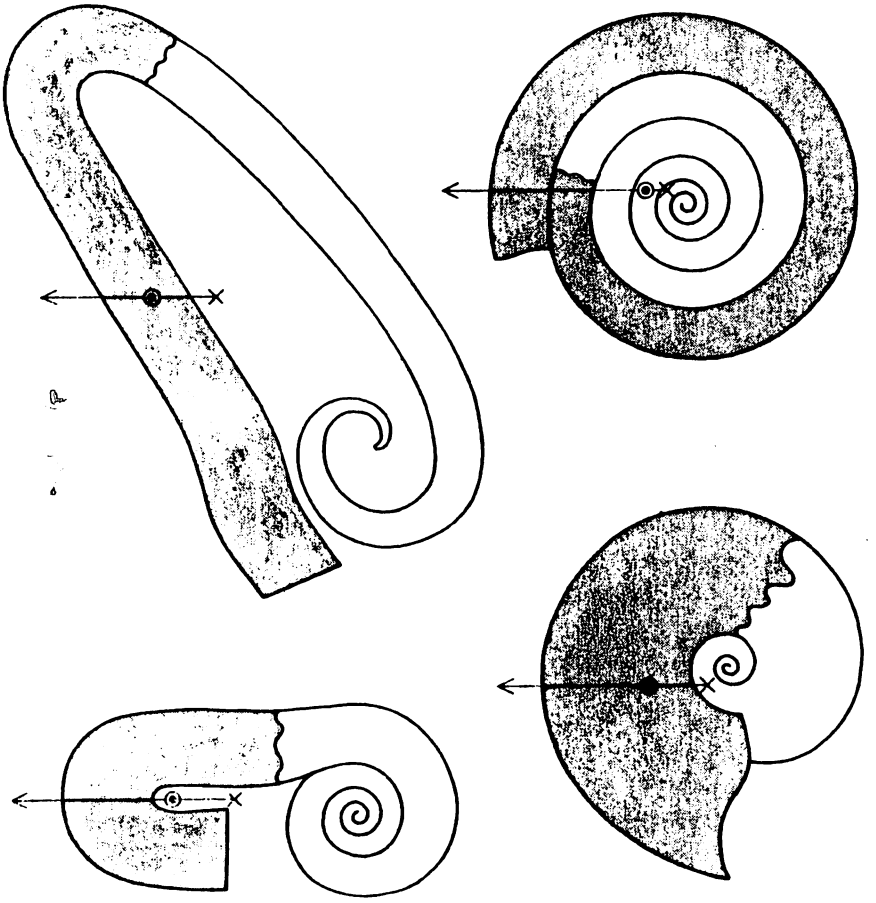


Fig. 2. Planispiral evolute ammonite conch showing internal view of suture support structures.

But the comparison must not be carried too far, because the ammonite, as one of the most versitile of marine creatures, adapted itself to nearly every ecological niche, even returning at times to the benthonic, bottom dwelling mode from which, as a mollusk, it had come. So that in some forms, as for example our California Shastoceras, the delicate buoyant early structures suddenly became transformed to a huge recurved hook formed of heavy shell material reminiscent of inoceramus in thickness, which must have sunk it quite solidly to the bottom against the feeble efforts toward buoyancy provided by its earlier endeavors.

Buoyancy determinations are a really critical consideration in attempting to establish an ecological format for each shell form assumed by the ammonite. For example, many of the heteromorphs because of their awkward, sprawling configuration were long considered by some to be no swimmers at all, but bottom-dwelling stick-in-the-muds. Well, great swimmers they may not have been, but floaters many of them certainly were as I, myself, can testify, having prepared dozens of them. Many Cretaceous forms present a devilishly ticklish job because of their paper-thin shells.

Swimming attitudes and mechanics have received much attention in research over the years. (Fig. 3 shows the work of Trueman who mathematically determined the attitude and swimming mechanics of typical ammonoid forms.



Dr. Raup (University of Chicago) developed the chart (Fig. 4) which explores the mathematics of planispiral coiling relative to mobility. Unfortunately the unpredictable ammonite has been known to change 'horses' in mid-Raup, some more than once, which unsimplifies matters.

Fig. 5 (courtesy Dr. Peter Ward, University California Davis) further explores dynamics of shell forms. Typically the discus shaped ones are assumed to have been able to dart about rather quickly while the others, like Nautilus, glided along quite sedately. Some must have been pretty much victims of currents except for their undoubted ability to change currents by moving up and down vertically, for which eventuality they had made elaborate structural preparation as before noted.

Failing speed and escape, some turned to armor for protection. Very durable 'horns' ornament the shell of Lytodiscoides--so durable they are often the only thing preserved. Most spiny protrusions (in the Cretaceous at least) were so delicate that they were not known with certainty to exist until the superior preservation of some of them in the California sediments brought it to light.

These spiny ornaments look formidable indeed, but are actually in most cases hollow and delicate. As one who has spent hundreds of hours trying to preserve them, I can testify that most are mounted on rounded bullae from which they detach themselves almost without effort--a la lizard tails. Some of the longer ones have similar invisible 'joints' at points along the shaft almost as though the animal, while wishing to look formidable, was hedging his bets against getting hung up by them among the 'weeds'.

The third major difference developed by the ammonite that characterizes his structure as against Nautilus and intermediate forms is position of the siphuncle tube. Ammonite siphuncles are ventral, (Fig. 2) and can be seen from the outside of the septate part of the conch whenever the shell is worn away.

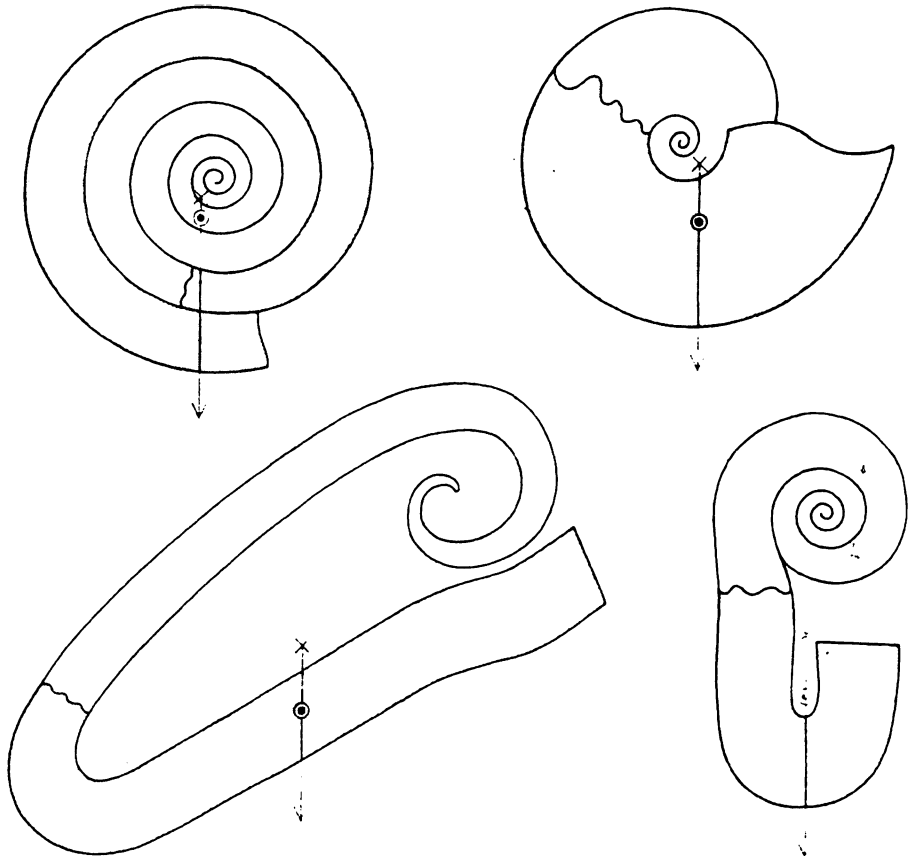


Fig. 3. Static stability of most heteromorphic shells is even greater than that of involute planispiral shells. Arthur E. Trueman of the University of Glasgow calculated the center of mass and the center of buoyancy for a variety of ammonite shells in the 1940's. The position of the center of mass is dictated by the spatial distribution of the body cavity (shaded area) and the position of the center of buoyancy by the spatial distribution of the phragmocone. The static stability of many heteromorphic shells is so great that the animals with these shells were probably capable of only modest changes in orientation. The normal orientation of some of these shells would dictate that the body of the animal face the surface rather than the bottom. This was the first clue that some heteromorphs, unlike their ancestors, were not bottom dwellers.

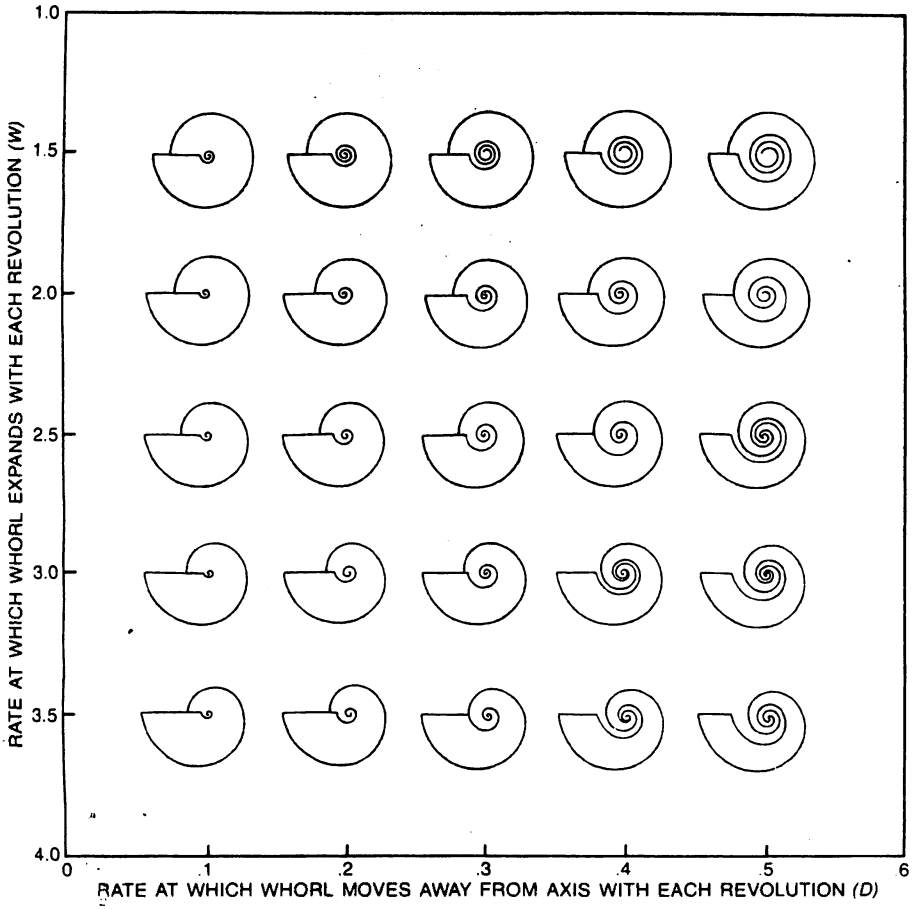


Fig. 4. Swimming ability of the planispiral ammonoids can be deduced from the shape of their shells. David M. Raup of the University of Chicago developed equations that will generate any shell shape based on a logarithmic spiral from four parameters of the shell. These computer-generated line drawings show the variation of shell shape with two parameters: the rate at which the cross section of the shell increases with each revolution (W) and the rate at which the cross section moves away from the coiling axis with each revolution (D). Low W, high D (evolute) shells are poorly adapted for swimming; high W, low D (involute) shells are comparatively well adapted. The center of mass of evolute shells, which is in the body cavity of the shell, tends to be close to the center of buoyancy, which is in the phragmocone: the walled-off part of the shell. The two centers are more widely separated in involute shells. Thrust from the directional water jet in the body cavity tends to rotate the shell away from its equilibrium position (in which the center of buoyancy is directly above the center of mass). The greater the separation of the centers of buoyancy and mass is, the faster the shell will reorient itself. Animals with involute planispiral shells therefore tend to be more agile and faster swimmers.

The reasons for this change of position are not perfectly understood, but must have had to do with more efficient regulation of the gas-liquid ratio in the chambers. The actual functioning involves osmotic gradients in siphuncular epithelium and a maze of other technical jargon best left to someone like Peter Ward[1], who breathes an atmosphere of such gobbledegook preferring it to oxygen.

I have not *run out* of things to say about ammonites, but I must stop somewhere. What better way than with a quote from a "down on the farm paleontologist" who said, "Ain't this just the most fascinatinest critter you ever seen?"

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[1] Scientific American, October 1980, p. 190.

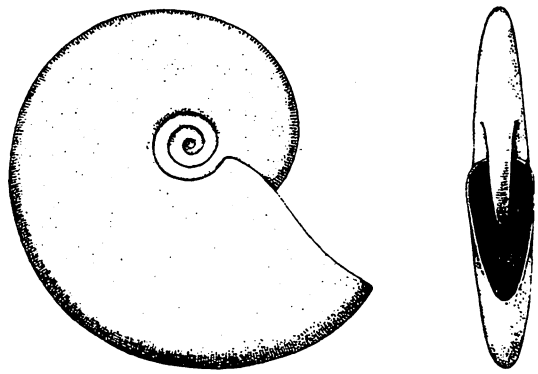


Fig. 5A. Streamlined planispiral shell type, a member of the genus Placenticeras. The smooth exterior and compressed cross section of the Placenticeras shell reduced drag, and the tight coiling of the shell increased its hydrodynamic stability; both factors made the animal a more agile and faster swimmer.

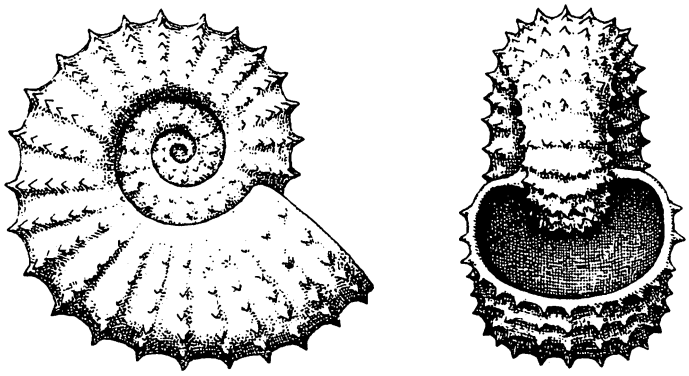
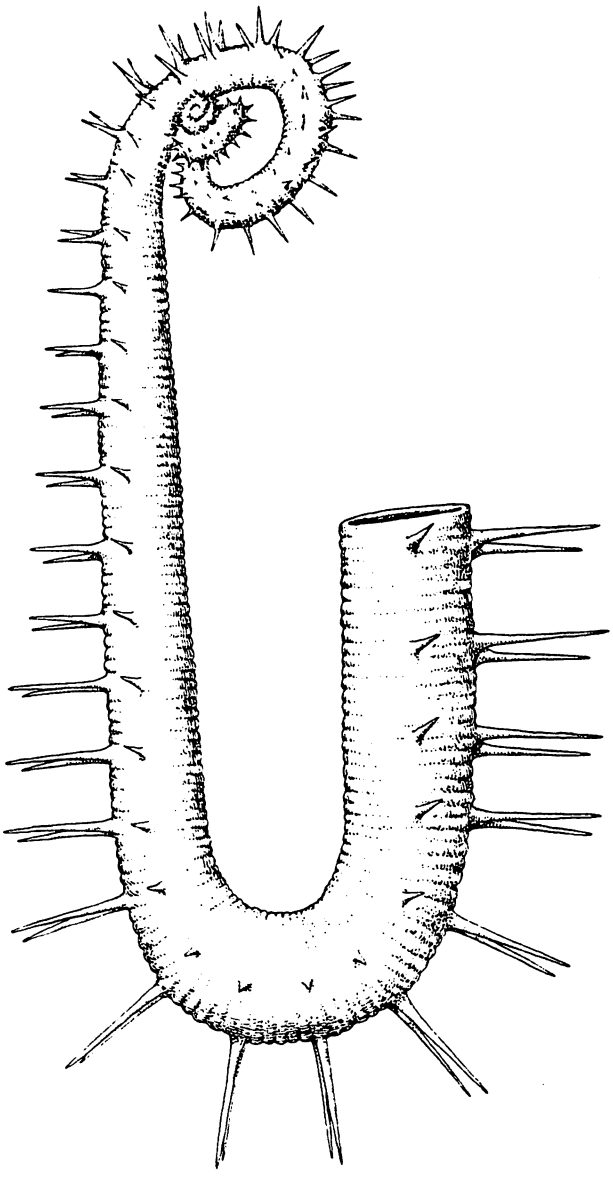
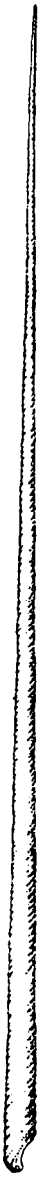


Fig. 5B. Heavily ornamented planispiral shell type, a member of the genus Douvilleiceras. The Douvilleiceras shell is less well adapted for swimming because of the rough exterior, the broad cross section, the comparatively loose coiling and the depressed umbilicus (the cavity around the axis of coiling). The spines and thickened ribs of the shell may, however, have served to discourage crabs, marine reptiles such as mosasaurs and other shell-crushing predators.

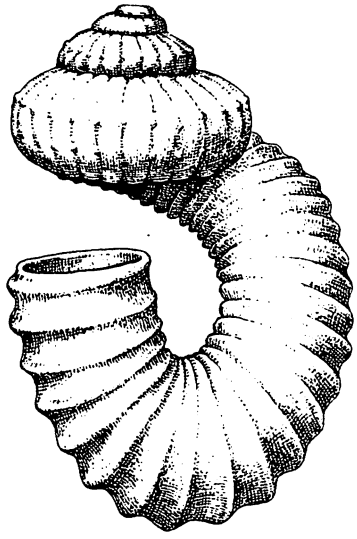
Figs. 5C. Heteromorph Ammonite Shells.



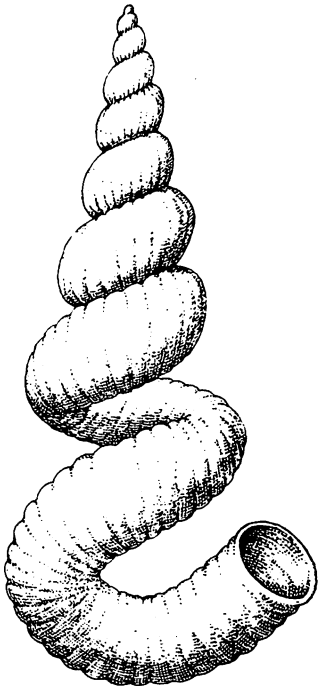
Anisoceras



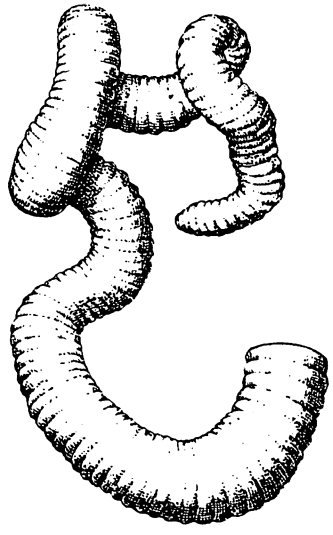
Sciponoceras



Nostoceras



Didymoceras



Nipponites

THE CHAMBERED NAUTILUS (1858)

This is the ship of pearl, which, poets feign
Sails the unshadowed main,--
The venturous bark that flings
On the sweet summer wind its purpled wings
In gulfs enchanted, where the Siren sings,
And coral reefs lie bare,
Where the cold sea-maids rise to sun their
streaming hair.

Its webs of living gauze no more unfurl;
Wrecked is the ship of pearl!
And every chambered cell,
Where its dim dreaming life was wont to dwell,
As the frail tenant shaped his growing shell,
Before thee lies revealed,--
Its irised ceiling rent, its sunless crypt un-
sealed!

Year after year beheld the silent toil
That spread his lustrous coil;
Still, as the spiral grew,
He left the past year's dwelling for the new,
Stole with soft step its shining archway
through,
Built up its idle door,
Stretched in his last-found home, and knew
the old no more.

Thanks for the heavenly message brought by thee.
Child of the wandering sea,
Cast from her lap, forlorn!
From thy dead lips a clearer note is born
Than even Triton blew from wreathed horn!
While on mine ear it rings,
Through the deep caves of thought I hear a
voice that sings:--

Build thee more stately mansions, O my soul,
As the swift seasons roll!
Leave thy low-vaulted past!
Let each new temple, nobler than the last,
Shut thee from heaven with a dome more vast,
Till thou at length art free,
Leaving thine outgrown shell by life's ar-
resting sea!

--Oliver Wendell Holmes

Cathy Baker
Geology Department
The University of Iowa
Iowa City, Iowa 52242

Minutes of a special meeting of the Board of Directors held at IBEW Local 405 Hall, 1211 Wiley Blvd. S.W., Cedar Rapids, Iowa, at 2:00 p.m., March 30, 1985.

All members of the Board of Directors were given written notice of special business that would be held today concerning a Resolution to adopt two Amendments to the Restated Articles of Incorporation. The Board Members present voted 7 for 0 against to adopt the two Amendments and to submit the same to a vote of all members of the Corporation at a special meeting of the members.

The Board also adopted a Resolution directing that a special meeting of the members of Mid-America Paleontology Society be held at the Union at Western Illinois University, Macomb, Illinois, at 7:00 p.m. on the 20th day of April, 1985, for the purpose of voting on whether to accept the proposed Amendments. The Board voted to give all members with voting rights a written notice of the meeting along with copies of the proposed Amendments. Members are to receive this mailing not less than 10 or more than 50 days prior to the meeting.

Respectfully submitted

Margaret Wallace, Secretary

(◊ ◊ ◊ ◊ ◊ ◊)

JOHN D. COOLIDGE III
564 Westchestnut St.
Lancaster, PA 17603
717-393-9908

Stone Mason. Will trade! Major interest Trilobites, starfish, L. Camb. fossils--all fossils Cambrian to Pleistocene. Has trilobites, starfish, Triassic & Devonian plants, many rare & unusual fossils. Wants to correspond and trade fossils with fellow collectors.

NED S. GILMORE
604 Elm Terrace
Riverton, NJ 08077
609-829-3683

Environmental Educator. Collecting 10 years, will trade. Major interest Cre. & Tert. fossils, locality assemblages, vintage books & publications about fossils. Has Cre. & Tert. fossils from NJ, DE, MD, NC. Wants to meet & trade with members with same interests.

ANTHONY JONES
P. O. Box 86
Brea, CA 92622
714-990-5073

Geologist. Will trade. Major interest ammonites, trilobites, echinoids and most vertebrate fossils. Has worldwide fossils to trade. Wants to learn more information on fossils of the U.S. and their preparation.

PHILLIP & DEBBIE REESE
716 North 2nd East
Brigham City, UT 84302
801-723-7348

Refrigeration Mechanic. Will trade. Main interest trilobites. Has trilobites and horn coral (Faberophyllum) for trade. Wants to meet other people with same interest and learn more about all fossils.

DOUGLAS SINCLAIR
308 5th Avenue
Charles City, IA 50616
- -

Microbiologist. Collecting 20 years. Interested in all aspects of paleontology centering with Devonian fauna and all trilobites in general. Contact me if you want to do any collecting in North Central Iowa.

The Mid-America Paleontology Society--MAPS--was formed to promote popular interest in the subject of paleontology; to encourage the proper collecting, study, preparation, and display of fossil material; and to assist other individuals, groups, and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

Membership in MAPS is open to anyone, anywhere who is sincerely interested in fossils and the aims of the Society.

Membership fee: January 1 through December 31 is $7.00 per household.

MAPS meetings are held on the 1st Saturday of each month (2nd Saturday if inclement weather). September, October, May, June, and July meetings are scheduled field trips. The August meeting is in conjunction with the Bedford, Indiana, Swap sponsored by the Indiana Society of Paleontology, the Indiana Chapter of MAPS. November through April meetings are scheduled for 2 p.m. in the Science Building, Augustana College, Rock Island, Illinois. MAPS Annual International Fossil Exposition is held in the Spring, and a second show in the Fall, Fossilmania, is sponsored by Austin Paleontological Society, a MAPS Affiliate.

MAPS official publication, MAPS DIGEST, is published 9 months of the year--October through June.

CYATHOCRINITES

MID-AMERICA PALEONTOLOGY SOCIETY

Mrs. Madelynne M. Lillybeck
MAPS DIGEST Editor
1039 - 33rd St. Ct.
Moline, IL 61265

Dated Material - Meeting Notice

FIRST CLASS MAIL